M.SC. OPTION PHILOSOPHY OF PHYSICS M.L.G. REDHEAD

The course is intended as an introduction to methodological and conceptual problems in modern physics.

The lectures will be supplemented by essay and discussion topics which together form an integral part of the course. However the lectures are designed to be self-contained and will not presuppose knowledge of the essay and discussion topics.

The syllabus for the course is as follows:

General Topics

1. Role of models and approximations.
2. Symmetry principles.
3. Crucial experiments and novel predictions.
4. Relation between mathematics and physics.
5. Conventionalism in physics.
6. Measurement and dimensions.
7. Particles and fields in classical physics.
8. Action-at-a distance versus fields versus potentials in classical electrodynamics.

Relativity and the Philosophy of Space and Time

1. Absolute versus relational theories of space and time.
2. Conventionality of the metric in continuous and discrete spaces.
3. Conventionality of topology.
4. The continuity of space and time.
5. The causal theory of time.
6. The nature of motion - Zeno's paradoxes.

2. Hidden variable theories.
3. No-hidden-variable theorems: von Neumann, Bell, Kochen and Specker.
4. Gleason's theorem.
5. Realistic interpretations of quantum mechanics.
6. Contextualism.
7. Non-locality - the Bell-Wigner theorems.
8. The Einstein-Podolsky-Rosen paradox.
9. The theory of measurement.
10. State preparation.
11. Latency, potentiality and propensity.
12. The uncertainty relations.
13. The Bohr-Heisenberg thought experiments.
14. The Copenhagen interpretation - complementarity.
15. Wave-particle duality.
16. Quantum logic and the paradoxes.
17. Identity and individuality - quantum statistics.
18. Relativistic quantum mechanics.
19. Quantum field theory and second quantization.
20. S-matrix theory and the bootstrap hypothesis.
21. Quark confinement and the methodology of particle physics.

Cosmology

1. Finite versus infinite universes - event and particle horizons.
2. The origin of the universe - big bang versus steady state approaches.
3. Black holes - the physics of singularities.
4. Cyclic universes - the topology of time.

7. Simultaneity in special relativity.
8. Winnnie's ϵ - relativity and absolute effects in the special theory.
9. Slow clock transport and the one-way velocity of light.
10. The clock paradox.
11. The K-calculus and other formulations of the special theory.
12. The mass-energy relation.
13. The principles of equivalence and general covariance.
14. Relativity on the rotating disc.
15. The origin of inertia - Mach's principle.
16. The Einstein field equations - Brans-Dicke theory.
17. Weyl's electomagnetic theory - conformal invariance.
18. Wheeler's geometrodynamics.
19. Gauge theories of gravitation.

Statistical Mechanics and the Reversibility of Time

1. Ergodic theory.
2. Ensemble theory.
3. H-theorems - classical and quantal.
4. Reversibility paradoxes.
5. Relation to thermodynamics.
6. The nature of entropy - the information theory approach.
7. The theory of branch systems.
8. Nomic irreversibility - K-meson decay and T violation.
9. Radiation theory - advanced and retarded potentials - pre-acceleration effects.
10. Retrocausation - tachyon paradoxes.

Quantum Mechanics

1. Formalism: states, observables, density matrices, projection operators.